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ORIGINAL RESEARCH

Psychomotor, cognitive, and functional variables in healthy older women and older women with Alzheimer's disease

Variáveis psicomotoras, cognitivas e funcionais em idosas saudáveis e com doença de Alzheimer

Variables psicomotoras, cognitivas y funcionales en ancianas sanas y con enfermedad de Alzheimer

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ABSTRACT | The Retrogenesis Theory (RT) describes the declines presented in Alzheimer's disease (AD) based on the stages of Piaget's neuropsychomotor development. The objective of this cross-sectional study was to evaluate and describe psychomotor and cognitive aspects, falls and the dependency relations between these variables according to RT in healthy older women and with probable Alzheimer's Disease (AD). Composed of 45 older women (27 healthy and 18 with mild AD), residing in São Paulo from 2016 to 2017. Anamnesis, Geriatric Depression Scale Yesavage (GDS-30), Montreal Cognitive Assessment (MoCA), Cambridge were used for evaluation Revised Cognitive Exam (CAMCOG-R), Berg Balance Scale (BBS), timed up and go test (TUGT) and Direct Functional Status Assessment (DAFS-BR). The Mann-Whitney U tests, Spearman correlation and multiple regression analysis were used with p <0.05. A loss order similar to that suggested by RT was observed in both groups. The lower the CAMCOG-R index, the greater the number of falls (p=0.03). Praxia items (p<0.00) and executive functions (p<0.00) of CAMCOG-R highly correlated with TUGT and BBS. A dependency relation between functionality/cognition is suggested; balance/cognition and correlation between risk of falling and cognitive performance in both groups. The observed losses are in line with what the RT proposes, but with different intensities between the groups. Longitudinal studies are necessary, with the use of imaging tests to validate RT in the loss patterns in older people with and without AD.

Keywords | Aging; Retrogenesis Theory; Alzheimer's Disease.

RESUMO | A teoria da retrogênese descreve os declínios apresentados na doença de Alzheimer a partir dos estágios do desenvolvimento neuropsicomotor de Piaget. O objetivo deste estudo transversal é avaliar e descrever aspectos psicomotores, cognitivos e quedas, investigando a relação de dependência entre essas variáveis de acordo com a teoria da retrogênese. A amostra foi composta por 45 idosas (27 saudáveis e 18 com Alzheimer fase leve), residentes em São Paulo entre 2016 e 2017. Para a avaliação foram utilizados: anamnese, Escala de Depressão Geriátrica de Yesavage (GDS-30), *Montreal Cognitive Assessment* (MoCA), *Cambridge Cognitive Exam-Revised (CAMCOG-R), Escala de Equilíbrio de Berg (EEB), timed up and go test* (TUGT), Avaliação Direta do Estado Funcional (DAFS-BR), teste U de Mann-Whitney, coeficiente de correlação de Spearman e análise de regressão múltipla com p<0,05. Observou-se ordem de perda semelhante à sugerida pela teoria da retrogênese nos dois grupos estudados. Quanto menor o índice CAMCOG-R, maior o número de quedas (p=0,03). Itens praxia (p<0,00) e funções executivas (p<0,00) do CAMCOG-R mostraram-se altamente correlacionados com o TUGT e a EEB. Sugere-se relação de dependência entre funcionalidade e cognição e equilíbrio e cognição, bem como correlação entre risco de queda e desempenho cognitivo nos dois grupos estudados. As perdas observadas estão de acordo com o que a teoria da retrogênese propõe, mas com diferentes intensidades entre os grupos. Estudos longitudinais são necessários, com uso de exames de

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imagem para validar a teoria nos padrões de perda em idosos com e sem doença de Alzheimer.
Palavras-chave | Envelhecimento; Teoria da Retrogênese; Doença de Alzheimer.

RESUMEN | La teoría de la retrogénesis describe el proceso de degeneración de la enfermedad de Alzheimer desde las etapas de desarrollo neuropsicomotor de Piaget. El objetivo de este estudio transversal es evaluar y describir los aspectos psicomotores, cognitivos y de caídas, y la relación de dependencia entre estas variables según la teoría de la retrogénesis. La muestra estuvo conformada por 45 ancianas (27 sanas y 18 con Alzheimer leve), residentes en São Paulo entre 2016 y 2017. En la evaluación se utilizaron: Anamnesis, Escala de Depresión Geriátrica de Yesavage (GDS-30), Evaluación Cognitiva de Montreal (MoCA), *Cambridge Cognitive Exam-Revised* (CAMCOG-R), Escala de Equilibrio de Berg (EEB), *timed up and go test* (TUGT), Evaluación Directa del Estado Funcional (DAFS-BR), prueba U de Mann-Whitney, coeficiente de correlación de Spearman y análisis de regresión múltiple con p<0,05. Se observó un orden de pérdida similar al sugerido por la teoría de la retrogénesis en los dos grupos estudiados. Cuanto menor es el índice CAMCOG-R, mayor el número de caídas (p=0,03). Los ítems de praxia (p<0,00) y las funciones ejecutivas (p<0,00) de CAMCOG-R demostraron estar altamente correlacionados con TUGT y EEB. Se sugiere una relación de dependencia entre funcionalidad y cognición y equilibrio y cognición, así como una correlación entre el riesgo de caídas y el desempeño cognitivo en los dos grupos estudiados. Las pérdidas observadas están acorde con lo que propone la teoría de la retrogénesis, pero con diferentes intensidades entre los grupos. Son necesarios estudios longitudinales utilizando pruebas de imagen para validar la teoría en patrones de pérdida en personas mayores con y sin la enfermedad de Alzheimer.
Palabras clave | Envejecimiento; Teoría de la Retrogénesis; Enfermedad de Alzheimer.

INTRODUCTION

The most common cause of dementia, responsible for 50% to 75% of all cases[1], is Alzheimer's disease (AD). It is a neurodegenerative, multifactorial process, which is characterized by the accumulation of beta-amyloid in senile plaques and phosphorylation of the tau protein in neurofibrillary tangles. These phenomena result in synaptic and neuronal losses that change cognitive functions and cause damages to memory, attention and reasoning[2,3]. In addition to cognitive impairment, older people with AD present motor and functional changes that directly affect their life quality and survival[4,5].

The first attempt to link dementia to human development, the theory of retrogenesis (RT) explains the declines presented in AD based on Piaget's stages of neuropsychomotor development[6]. According to the theory, the cognitive losses in AD happen in the reverse order of the neuropsychomotor acquisition proposed by Piaget, that is, in early stages the most complex skills are lost and consequently cognitive demands increase, while in later stages primitive skills are required and then there are less cognitive demands[6,7].

Although RT is already well defined, it describes only cognitive and functional declines that are isolated, without evaluating the relation between cognitive and motor or cognitive and functional variables. Also, the order of motor losses in AD and the influence of cognition on functional and motor variables in the early stages of the disease are unclear, as well as in the risk of falls. The hypotheses of this study are: (1) the early losses (cognitive, motor and functional) in AD would be the ones with more complex functions, related to the loss of specific cognitive functions (executive and praxis); (2) the losses would occur in reverse order to the neuropsychomotor acquisition model proposed by Piaget; (3) it would be the correlation and relation of dependency between cognition and functionality, cognition and motor aspects. In order to clarify these hypotheses, this study evaluates and describes psychomotor, cognitive and functional aspects using the RT model to investigate the relation of dependency between these variables in health older women in and older women diagnosed with probable early stage AD.

METHODOLOGY

Population and study design

This is a cross-sectional study with a sample consisting of women aged between 60-90 years old, residents of São Paulo and its Metropolitan Region, Brazil, and members of two support services for the older population: "VivaVida", a community center of the Fundação Nossa Senhora

Auxiliadora do Ipiranga – Funsai, and the facility-center Associação de Familiares e Amigos de Idosos (Afai).

To participate in the study, the older women should not have decompensated sensory changes (severe vision impairment without the use of glasses, decreased hearing acuity without the use of prosthesis or untreated vestibular changes), severe orthopedic changes (severe osteoarthritis, fracture with deformity, rheumatic disease deformity), and neurological changes (Parkinson disease and cerebrovascular accident). The presence of these alterations was evaluated in the initial anamnesis. Older women who missed an appointment or refused to complete an evaluation were also excluded, as well as older women with diagnosis and/or suspicion of depression, detected through the Geriatric Depression Scale of Yesavage (GDS-30)[8-10].

Initially, 70 older women were recruited. Of these, 25 were excluded: 9 due to neurological changes; 4 due to score GDS-30>11; 2 due to several orthopedic changes; 2 by presenting a moderate or advanced stage of AD; 3 did not presented a dementia diagnostic; and 5 who missed at least one of the appointments. The 45 selected older women were divided in two groups: healthy (GIH=27) and with AD (GIA=18).

Instruments

The battery of tests consisted of pre-elaborated anamnesis of sociodemographic information, clinical conditions (comorbidities and number of medications used), practice of physical activity and history of falls.

For the cognitive evaluation, the instruments used were the *Montreal Cognitive Assessment* (MoCA) – a short-term screening tool for mild cognitive impairment (MCI)[11,12], and *Cambridge Cognitive Exam-Revised* (CAMCOG-R), whose objective is to detect early stages of dementia syndromes and predict the development of the disease. In this study, CAMCOG-R was used specifically to evaluate executive and praxis functions[13-15].

For the motor evaluation, the instruments used were Berg Balance Scale (BBS), which evaluate the performance of functional balance in 14 ordinary items of daily living in a standard-order[16], and *timed up and go test* (TUGT), which evaluates the mobility and the balance necessary to get up from a chair, walk for three meters, return and sit down[17].

For the functional evaluation, it was used The Direct Assessment of Functional Status (DAFS-BR), which directly examines a wide range of functional skills in older patients with and without cognitive impairment[18,19]. All scales have been validated to be used in Brazil.

Procedures

The evaluations were divided in two meetings with the duration of 1 hour and 30 minutes each one. In the first, the anamneses were made regarding sociodemographic, clinical and falls data. The instruments MoCA and BBS were applied in this meeting. In the second meeting, CAMCOG-R, TUGT and DAFS-BR were applied. The tests were made by a trained evaluator, in order to minimize the possible deviations. The data collection and the applications of the scales happened between February and June of 2017.

In the case of older women with AD, clinical information was previously collected with relatives, who also confirmed the data of the medical records. Only the older adults with AD diagnosed by a geriatrician or neurologist that presented staging according to the *Clinical Dementia Rating Scale* (CDR-1: mild stage/early stage of the disease) were included in the study. The older adults and their legal guardians (when necessary) signed the Informed Consent Form.

Statistical analysis

The results were analyzed in the software *SPSS Statistics* for *Windows*, version 17.0 (Chicago: SPSS Inc., 2008), defining the value-p<0,05 as the significance level. The sociodemographic variables and the tests scores underwent descriptive analysis.

To analyze the data distribution, Levene and Shapiro-Wilk's tests were applied., The Cliff Delta test was used to compare groups and evaluate the effect size. To analyze the association between two categorical variables were used the Pearson's chi-squared test and the Fisher's exact test.

The Mann–Whitney U test was applied to evaluate the differences between observational test scores and the number of falls between the groups. Spearman's correlation analysis was performed between the test scores and the number of falls. Due to the sample's characteristics, it was used bootstrap regression (n=10.000), stratified by the group variable and with bias correction.

Sample description

Considering the sampling error of 5%, the sample size demonstrated a minimum of 10 older women in each group. Thirty-five older women were evaluated, 27 from GIH and 18 from GIA, in the early stage of the disease (CDR 1). The main sociodemographic, psychomotor,

cognitive and functional characteristics are described in Table 1. It was not observed a significant statistical difference between the groups concerning their income (p=0,18), but the items schooling and age presented significant differences between the groups (p=–0,51 and p=0,33, respectively). Concerning schooling, besides the difference, Cliff's Delta Calculator showed a score of 0,33 (which represents a little effect). Regarding the age, the analysis of covariance (ANCOVA) showed the following results: there is no effect of age on the motor scale result TUG [F (1, 42)=2,185; p=,147]; of age on cognitive scale result MoCA [F (1, 42)=,362; p=0,551]; of age on Berg balance scale result [F (1, 42)=3,185; p=0,083]; of age on cognitive scale result CAMCOG-R [F (1, 42)=,081; p=,778]; and of age on functional scale result DAFS-BR [F (1, 42)=,115; p=,737].

Information about health aspects was collected and analyzed. Were found high percentages of systemic arterial hypertension (16,4% in GIH, and 16,3% in GIA, p=0,01), dyslipidemia (16,4% in GIH, and 16,3% in GIA, p=0,01), orthopedic changes (26,9% in GIH, and 8,7% in GIA, p=0,1), osteoporosis (10,4% in GIH, and 13% in GIA, p=0,01), and visual alterations (9% in GIH, and 13% in GIA, p=0,00).

Table 1. Sociodemographic, clinical characteristics and scales scores (cognitive, motor and functional) of the evaluated groups presented as average and standard deviation

Sample characterization and scales score	GIH	GIA	p	Cliff Delta
Age (years)	79,4±5,2	84,1±5,1	0,00	-0,51
Schooling (year)	11,0±3,4	9,4±2,3	0,04	0,33
Comorbidities (number)	2,4±1,4	5,1±1,9	0,00	-0,72
Medications (number)	1,9±0,9	3,6±1,0	0,00	-0,78
Physical Activities (number)	2,78±1,0	1,89±0,6	0,00	0,50
Falls (number)	0,2±0,4	0,7±0,7	0,02	-0,33
MoCA FE	3,6±1,2	1,5±1,1	0,00	0,74
MoCA Total	23,7±3,2	11,3±3,5	0,00	0,99
TUGT	11,8±2,7	22,6±6,5	0,00	-0,97
BBS Total	50,1±4,2	36,2±8,2	0,00	0,92
CAMCOG-R Praxis	10,2±1,8	6,9±2,6	0,00	0,69
CAMCOG-R FE	13,8±3,3	5,2±1,8	0,00	0,98
Total CAMCOG-R	92,1±9,6	50,3±11,9	0,00	1,00
DAFS-BR Orientation	16,0±0,0	8,7±3,7	0,00	0,94
DAFS-BR Communication	14,1±1,1	8,5±2,5	0,00	0,94
DAFS-BR Money	24,5±4,3	10,3±3,7	0,00	0,98
DAFS-BR Shopping	15,3±3,8	3,0±2,4	0,00	0,93
DAFS-BR Clothes/ Hygiene	13,0±0,0	11,6±2,3	0,00	0,61
DAFS-BR Food	10,0±0,0	9,2±1,2	0,00	0,33
DAFS-BR Total	93,0±7,8	51,6±11,1	0,00	0,99

GIH: Group of healthy older adults. GIA: Group of older adults with Alzheimer's disease. MOCA FE: Executive functions of *Montreal Cognitive Assessment* items; TUGT: *timed up and go test*; BBS: Berg Balance Scale; CAMCOG PRAXIA: praxis item of the *Cambridge Cognitive Exam-Revised*; CAMCOG FE: executive functions item of *Cambridge Cognitive Exam-Revised*; DAFS-BR: Direct Functional Status Assessment– Brazilian Version. p<0,05. Mann-Whitney U Test and Cliff Delta.

RESULTS

Patterns of psychomotor, cognitive and functional loss

The reference values of cognitive, motor and functional tests were compared with the means obtained from GIH and GIA. After that, the items were classified in the following way: from the highest to the lowest percentage difference between the reference and the values obtained in the groups. Figure 1A shows patterns of cognitive loss. In the GIH, the cognitive functions with the highest percentage difference between the values obtained and the reference values were: praxis, executive functions and abstraction. In the GIA, the functions were: abstraction, memory, executive functions, and Cliff Delta=–1.

Figure 1B shows patterns of motor loss. In both groups, GIH and GIA, the two motor skills with the highest percentage difference between the values obtained and the reference values were: unipodal support and tandem. The third skill in the GIH was lean forward, while in GIA was to turn 360 degrees with the Cliff Delta=–1 effect.

Figure 1C shows patterns of functional loss. In the GIH, the functions with the highest percentage difference between the values obtained and the reference values were to calculate the account balance, give the correct change, and memorize six items from a list. In GIA, the functions were using the phone, give the correct change and memorize six items of a supermarket list with Cliff Delta=–1.

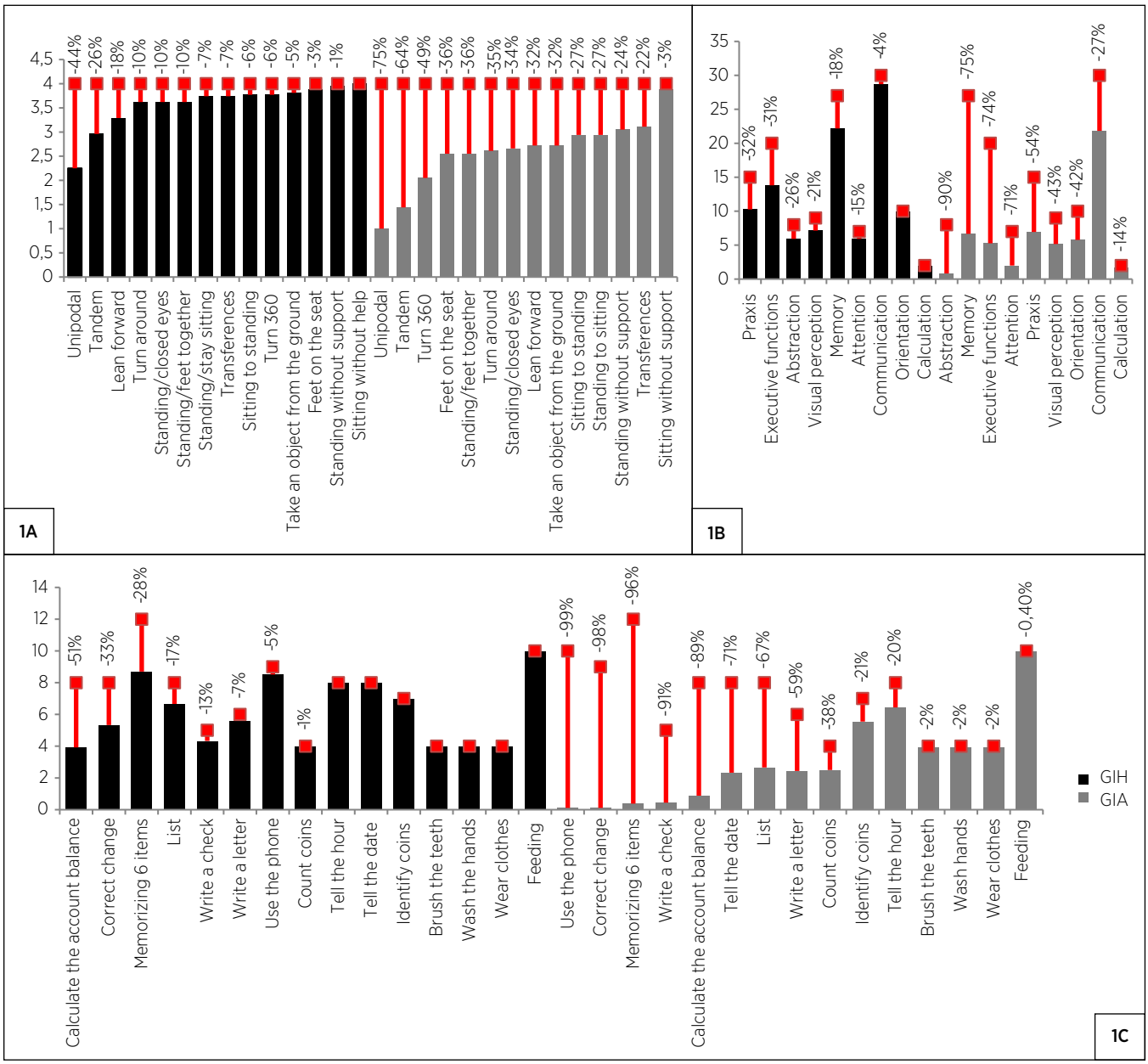

Figure 1. Comparative graph with difference between the expected values and the averages obtained in the motor, cognitive and functional aspects. 1A: motor loss patterns; 1B: cognitive loss patterns; and 1C: functional loss patterns. The unit of measurement adopted in the graph is equal to the points. The columns represent the averages obtained by the groups and the red lines represent the difference to the expected values. * GIH: group of healthy older women; GIA: group of older women with Alzheimer's Disease.

Correlation and dependence between cognitive, motor and functional variables

In order to detect possible correlations between cognitive, motor and functional scales, the Spearman's correlation test was performed. The item praxis (ρ=–0.56; p-value<0.00) and the item executive functions (ρ=–0.80; p-value<0.00) of CAMCOG-R were highly correlated with TUGT (gait speed). The same happened with Berg (balance) – praxis (ρ=–0,59; p-value<0,00) and

executive functions (ρ=-0,76; p-value<0,00). This suggests a probable relationship between these cognitive functions and the risk of falling. A strong correlation was also found between the items of the functionality scale DAFS-BR with the cognitive scales MoCA and CAMCOG-R, specially for the items praxis (ρ=0,76; p-value<0,00) and executive functions (ρ=0,88; p-value<0,00).

In order to evaluate the dependency relation of the variables chosen in the two groups, two models were constructed: (1) BERG TOTAL = GROUP + CAMCOG-R TOTAL, and (2) DAFS-BR TOTAL = GROUP + CAMCOG-R TOTAL. The adjustments to the models were excellent, with (a) R^2 of model (1)=0,81, and R^2 of model (2)=0,96; (b) Durbin-Watson close to 2 in both models, which indicates that heterogeneity and autocorrelation were not problems; (c) VIF<10 measure in both models, which indicates that multicollinearity was not a problem; and, finally, the (d) absence of outliers.

In the evaluation of the dependency relation between Berg and CAMCOG-R scales, statistical significance was observed: in each increased point in the total score of CAMCOG-R, there is an increase in the total Berg score in 0,27 (p-value<0,01). There was no difference between the groups, that is, the dependency relation between cognition, balance and risk of falls was similar for healthy older women and older women with AD.

In the evaluation of the dependency relation between DAFS-BR and CAMCOG-R scales, it was observed that the increase of one point in the total of CAMCOG-R implied an increase of 0.69 (p-value<0,01) in total DAFS-BR. There was a statistical difference between the groups. In the GIH, the increase of one point in the total of CAMCOG-R resulted in an increase of 12,49 points in DAFS-BR.

DISCUSSION

Following the logic proposed by RT, the development becomes regression, the evolution become involution, and ascending vertical organization become descending vertical disorganization[6,7,20,21]. The objective of this study was to evaluate and describe psychomotor, cognitive, functional aspects, and the dependency relation between these variables in older healthy women and women diagnosed with probable AD in early stage. The hypotheses tested were: that the firsts losses (cognitive, motor and functional) in AD would be of more complex functions; that such losses would be in an inverse order of the neuropsychomotor development model proposed by Piaget; and that there would be a correlation and dependency relation between cognition and functionality, and between cognition and motor aspects.

From the point of view of functionality, evaluated by DAFS-BR scale, the instrumental activities (calculate the account balance, memorize, select items of a shopping list, calculate change, use the phone, write checks) were those with the lowest scores. The difference, besides the intensity of the losses, lies in the fact that in the GIA the most involved activities were those that directly involved memory, executive functions and praxis (memorizing items, using the telephone). In the statistical analysis, there was a dependency relation between functionality and cognition, since the increase of one point in CAMCOG-R total implied in an increase of (p-value<0,01) in DAFS-BR total. There was a statistical difference between GIH and GIA. In GIH, the increase of one point in the total CAMCOG-R resulted in an increase of 12,49 points in the DAFS-BR. This indicates a probable relation between the cognitive skill and the skill to perform instrumental activities (more complex). It is important to mention that this was the expected result, since the diagnosis of the disease depends on the progressive functional decline associated with cognitive impairment, and DAFS-BR is a scale that measure the functionality.

Reisberg et al.[6] suggested this same inversion of functional stages based on the data obtained by other instrument: *Functional Assessment Staging Test* (FAST). The functional losses observed happened in the following order: loss of working ability, necessity of assistance in complex activities, help to choose clothes, assistance with bath and food[6,20]. A cross-sectional study made in the South of Brazil found very similar results to those obtained in this study: the more complex instrumental activities were affected in the early stage of AD – 2% of the older evaluated presented total dependency for instrumental activities of daily living (IADL) already in the mild stage of the disease. In the severe phase, this percentage rose to 29,3%[22].

Studies suggest that executive dysfunction is the central factor involved in problems in activities of daily living (ADL). This dysfunction can be associated with cortical atrophy observed in severe stages of AD that occurs in motor areas of the frontal cortex and in areas of sensorimotor integration, directly interfering in this function[23]. Losses in fine motor skills (agility and precision), for example, directly impair functionality and performance in everyday tasks[24]. Praxis circuit involves

the cortical system of the dominant hemisphere, which in turn activates the pre-motor cortex of the left hemisphere. When this hemisphere is activated, a signal is sent to the right hemisphere, where the corpus callosum transmits the signal to the motor cortex of the right hemisphere, allowing a practical act[25]. Despite the common association with vascular dementias, a study by Yoshii et al.[26] found that the impairment of praxis occurred at both the cortical and subcortical levels[26].

Regarding the cognition, this research used two instruments of evaluation: MoCA and CAMCOG-R, considering the strong correlation between the scales (ρ=0,920, value-p<0,01) and the fact that CAMCOG-R scale presents a higher number of evaluated cognitive functions (specially executive and praxis functions) for subsequent correlation analyzes. In an analysis of cognitive functions with lower scores, the GIH showed changes (not indicating impairment) in: praxis, executive functions, abstraction and visual perception. The GIA presented significant losses in abstraction, memory, executive functions and attention. Such information is in accordance with the cognitive declines described in the AD[27,28]. The recent memory would be initially affected with consequent spatial disorientation and difficulty in learning, coding, recollecting, recovering and sequencing actions[29,30]. The impairment of executive functions would be justified by the involvement of frontal regions in the early stages of AD[31,32].

The impairment of cognitive functions can also influence the motor and balance functions, as well as the risk of falls. Evaluating and comparing the means obtained between the groups in TUGT, it was observed that the average gait speed of GIA was much lower than that found in the GIH. This means that older population with AD made the test for much longer time (slowing down) which suggests a higher risk of falling. A previous study found similar results applying the same scale in older adults with AD in mild stage[33]. Older patients with early AD tend to increase the modulation of the locomotor pattern in relation to the pre-dementia stage, which produces a more cautious gait and, consequently, reduces its speed[34]. The reduce of gait speed was also corroborated by a longitudinal study carried out in 2017, which observed how older adults with MCI and AD in mild stage presented lower gait speed when compared with healthy older adults, although this reduction was not able to predict falls in any of the evaluated groups[35].

In the evaluation of balance by BBS, the final average scores obtained in the groups differed significantly. The GIA presented lower scores than GIH, indicating greater changes in balance and greater risk of falling. Other studies corroborate this research, finding similar results[36].

The balance items most impaired in the GIA were those that required greater motor control (complex posture) or motor planning (sequence of movements), while lower postures (seated position) did not change. This observation can suggest a pattern of motor loss and refers to what was proposed by RT: the impairment of lower postures is only noticed in the severe stage of the disease, when the older adults usually fall asleep and assume flexing postures associated with primitive reflexes.

The both scales chosen to evaluate the risk of falls showed to be highly correlated (ρ=–0,89). For the linear regression analysis, BBS was used, which divides the balance in motor stages with different difficulty levels.

A correlation was found between CAMCOG-R score and the number of falls in the two groups (ρ=–0,32, p-value=0,03), that is, the lower the total score, the greater the number of falls observed. Previous studies indicate that cognitive decline is a variable that can influence directly the risk of falls in older adults[37,38]. In 2017, Lee et al.[37] investigated the association between subcortical gray matter volumes and postural instability in AD, noting that all brain structures, except the pale globe, were smaller compared with the control group. The older adults with AD presented bad performance in the unilateral posture tests and sensory organization on the balance platform. This same group showed an increase in the frequency of falls[37].

In the mild stages of AD, the risk of falls is similar to the risk of falls in healthy older adults[36]. Ansai et al.[39], in a cross-sectional study, also found no significant differences in gait and risk of falls in groups of older people without cognitive impairment, with MCI and with mild AD, but observed significant difference in the double task in the group with mild AD. This finding points to the possible interference of cognitive components in episodes of falls, since the double task involves executive functions[39]. However, as the disease progresses and compromises the cortical areas, simpler motor components, such as sitting and getting up (in the moderate stage), are also compromised, which further increases the risk of falls[40]. It must be taken into account that in the moderate and severe stages of the disease, the use of antidepressant and antipsychotic medications can predispose an even greater number of falls[41].

Both executive and praxis functions were highly correlated with the risk of falls evaluated by TUGT

and BBS. A dependency relation was observed between CAMCOG-R and BBS: where in each point that occurred an increase in the total score of CAMCOG-R, also occurred an increase in the score of BBS. However, there was no difference between the groups. The relation between dependency, cognition, balance, and risk of falls was similar in healthy women and in older women with AD. A previous study found a negative correlation between cognitive function of MMSE and Agility and Dynamic Balance (ADB) in older patients with AD, also indicating that performance in motor tests could be directly associated with the patient's level of cognitive functions[42]. Other study found that injuries of cognitive functions could proportionally increase gait dysfunction and consequently increase the risk of falls[43].

Understanding the order of the loss of cognitive, functional and motor functions, and the relation between them, can help in the development of more assertive therapies, which can be applied in the beginning of AD. The loss of complex cognitive functions, besides RT, can be explained by global neurodegeneration and consequent loss of connectivity between brain networks. Taking this into consideration, it would be interesting if future studies conduct longitudinal monitoring and results monitoring through neuroimaging tests.

This study presents some limitations. As a cross-sectional study, it was not possible to compare the older population over time. Hence, longitudinal studies are suggested to better understand the patterns of loss in AD and to validate RT.

In this study, the group GIA presented an average age and comorbidities significantly higher than GIH, which suggests a greater functional and motor impairment. It is important to mention the difficulty in the early diagnosis of patients with AD and the difficulty to access these patients.

CONCLUSION

It was observed a dependency relation between functionality and cognition, and between balance and cognition, as well as correlation between the risk of falling and the cognitive performance. Furthermore, it was possible to suggest an order in the functional, cognitive and motor losses that meets the proposed theory. According to this theory, in the early stages of AD occur the losses of instrumental functional skills, complex cognitive functions (memory, executive functions, and praxis), reduced gait speed, and reduced balance in postures that require more planning and motor control, resulting in a greater chance of falling. There was a high correlation between the items praxis and executive functions of CAMCOG-R with TUGT and BBS and the risk of falls.

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REFERENCES

1. Alzheimer's Disease International. World Alzheimer Report 2015: the global impact of dementia: an analysis of prevalence, incidence, cost and trends. London: Alzheimer's Disease International; 2015.
2. Delaby C, Gabelle A, Blum D, Schraen-Maschke S, Moulinier A, Boulanghien J, et al. Central nervous system and peripheral inflammatory processes in Alzheimer's disease: biomarker profiling approach. Front Neurol. 2015;6:181. doi: 10.3389/fneur.2015.00181
3. von Bernhardi R, Cornejo F, Parada GE, Eugenín J. Role of TGFβ signaling in the pathogenesis of Alzheimer's disease. Front Cell Neurosci. 2015;9:426. doi: 10.3389/fncel.2015.00426
4. Ardilla A. Normal aging increases cognitive heterogeneity: analysis of dispersion in WAIS-III scores across age. Arch Clin Neuropsychol. 2007;22(8):1003-11. doi: 10.1016/j.acn.2007.08.004
5. Farfel JM. Fatores relacionados à senescência e à senilidade cerebral em indivíduos muito idosos: um estudo de correlação clinicopatológica [thesis]. São Paulo: Universidade de São Paulo; 2008. 157 p.
6. Reisberg B, Franssen EH, Hasan SM, Monteiro I, Boksay I, Souren LEM, et al. Retrogenesis: clinical, physiologic and pathologic mechanisms in brain aging, Alzheimer's and other dementing processes. Eur Arch Psychiatric Clin Neurosci. 1999;249(3):28-36. doi: 10.1007/pl00014170
7. Reisberg B, Franssen EH, Souren LEM, Kenowsky S, Jamil IA, Anwar S, Auer S. Alzheimer's disease. In: Flanagan SR, Zaretsky H, Moroz A, editors. Medical aspects of disability: a handbook for the rehabilitation professional. 4th ed. New York: Springer Publishing Company; 2011. p. 25-65.
8. Yesavage JA, Brink TL, Rose TL, Lum O, Huang V, Adey M, Leirer VO. Development and validation of a geriatric depression screening scale: a preliminary report. J Psychiatr Res. 1982-1983;17(1):37-49. doi: 10.1016/0022-3956(82)90033-4
9. Farrel C. Poststroke depression in elderly patients. Dimens Crit Care Nurs. 2004;23(6):264-9. doi: 10.1097/00003465-200411000-00007

10. Roman MW, Callen BL. Screening instruments for older adult depressive disorders: updating the evidence-based toolbox. Issues Ment Health Nurs. 2009;29(9):924-41. doi: 10.1080/01612840802274578

11. Nasredinne ZS, Phillips NA, Bédirian V, Charbonneau S, Whitehead V, Collin I, et al. The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment. J Am Geriatr Soc. 2005;53(4):695-9. doi: 10.1111/j.1532-5415.2005.53221.x

12. Smith T, Gildeh N, Holmes C. The Montreal Cognitive Assessment: validity and utility in a memory clinic setting. Can J Psychiatry. 2007;52(5):329-32. doi: 10.1111/j.1532-5415.2005.53221.x

13. Paradela, EMP. Adaptação transcultural para o português do Teste Cognitivo Cambridge Revisado e desempenho do teste em idosos ambulatoriais [thesis]. Rio de Janeiro: Universidade do Estado do Rio de Janeiro; 2007. 180 p.

14. Pereiro AX, Ramos-Lema S, Juncos-Rabadán O, Facal D, Lojo-Seoane C. Normative scores of the Cambridge Cognitive Examination-Revised in healthy Spanish population. Psicothema. 2015;27(1):32-9. doi: 10.7334/psicothema2014.169

15. Moreira IFH, Bezerra AB, Sudo FK, Alves GS, Ericeira-Valente L, Tiel C et al. CAMCOG: valores das subescalas em idosos normais com níveis diferentes de escolaridade: aspectos preliminares. Rev Bras Neurol. 2013;49(1):32-6.

16. Miyamoto ST, Lombardi I Jr, Berg KO, Ramos LR, Natour J. Brazilian version of the Berg balance scale. Braz J Med Biol Res. 2004;37(9):1411-21. doi: 10.1590/S0100-879X2004000900017

17. Hofheinz M, Schusterschitz C. Dual task interference in estimating the risk of falls and measuring change: a comparative, psychometric study of four measurements. Clin Rehabil. 2010;24(9):831-42. doi: 10.1177/0269215510367993

18. Loewestein DA, Amigo E, Duara R, Guterman A, Hurwitz D, Berokowitz N et al. A new scale for the assessment of functional status in Alzheimer's disease and related disorders. J Gerontol. 1989;44(4):114-21. doi: 10.1093/geronj/44.4.p114

19. Pereira FS. Executive function and functional status in normal elderly, mild cognitive impairment and Alzheimer disease [dissertation]. São Paulo: Universidade de São Paulo; 2009.

20. Reisberg B, Franssen H, Souren LEM, Auer SR, Akram I, Kenowsky S. Evidence and mechanisms of retrogenesis in Alzheimer's and other dementias: management and treatment import. Am J Alzheimers Dis Other Demen. 2002;17(4):202-12. doi: 10.1177/153331750201700411

21. Rogers H, Lasprilla JCA. Retrogenesis theory in Alzheimer's disease: evidence and clinical implications. An Psicol. 2006;22(2):260-66.

22. Haskel MVL, Bonini JS, Santos SC, Silva WCFN, Bueno CFO, Bortolanza MCZ, Daniel CR. Funcionalidade na Doença de Alzheimer leve, moderada e grave: um estudo transversal. Acta Fisiatr. 2017;24(2):82-85.

23. Pini L, Pievania N, Bocchetta M, Altomare D, Bosco P, Cavedo E, et al. Brain atrophy in Alzheimer's Disease and aging. Ageing Res Rev. 2016;30:25-48. doi: 10.1016/j.arr.2016.01.002

24. Andreatto CAA. Percepção de tempo e outras funções cognitivas, funcionalidade motora e o nível de atividade física em idosos com Doença de Alzheimer no estágio leve [dissertation]. Rio Claro: Universidade Estadual Paulista Júlio de Mesquita Filho, 2013. 126 f.

25. Moreira L, de Paula JJ. Praxia e visioconstrução. In: Malloy-Diniz L, Fuentes D, Mattos P, Abreu N, editors. Avaliação neuropsicológica. 2nd ed. Porto Alegre: Artmed; 2018. p. 106-11.

26. Yoshii F, Kawaguchi C, Kohara S, Shimizu M, Onaka H, Ryo M, Takahashi W. Characteristic deterioration of ADAS-Jcog subscale scores and correlations with regional cerebral blood flow reductions in Alzheimer's disease. Neurol Sci. 2018;39(5):909-18. doi: 10.1007/s10072-018-3277-6

27. Arango-Lasprilla JC. Alteraciones neuropsicológicas en la enfermedad de Alzheimer. In: Londoño PG, editor. Memoria y demencias. Neiva: Universidad Surcolombiana; 2004. p. 77-86.

28. Mckhann GM, Knopman DS, Chertkow H, Hyman BT, Jack CR Jr, Kawas CH, et al. The diagnosis of dementia due to Alzheimer's disease: recommendations from the National Institute on Aging-Alzheimer's Association workgroups on diagnostic guidelines for Alzheimer's disease. Alzheimers Dement. 2011;7(3):263-69. doi: 10.1016/j.jalz.2011.03.005

29. Borges S, Aprahamian I, Radanovic M, Forlenza OV. Psicomotricidade e retrogênese: considerações sobre o envelhecimento e a doença de Alzheimer. Rev Psiquiatr Clín. 2010;37(3)131-7. doi: 10.1590/S0101-60832010000300007

30. Caramelli E, Zinger-Vakin T, Morad M, Merrick J. Can physical training have an effect on well-being in adults with mild intellectual disability? Mech Ageing Den. 2005;126(2):299-304. doi: 10.1016/j.mad.2004.08.021

31. Yaari R, Corey-Bloom J. Alzheimer's disease. Semin Neurol. 2007;27(1):32-41. doi: 10.1055/s-2006-956753

32. Ávila R, Miotto EC. Funções executivas no envelhecimento normal e na doença de Alzheimer. J Bras Psiquiatr. 2003;52(1):53-63.

33. Pedroso R. Relação entre nível de atividade física, cognição, processamento da informação e funcionalidade motora de idosos no estágio leve da doença de Alzheimer [dissertarion]. Rio Claro: Universidade Estadual Paulista Júlio de Mesquita Filho, 2012. 149 p.

34. Scarmeas N, Albert M, Brandt D, Blacker G, Hadjigeorgiou A, Papadimitriou B et al. Motor signs predict poor outcomes in Alzheimer disease. Neurology. 2005;64(10):1696-703. doi: 10.1212/01.WNL.0000162054.15428.E9

35. Massé FAA. Velocidade da marcha como preditor de quedas em idosos com transtorno neurocognitivo e doença de Alzheimer [dissertation]. São Carlos: Universidade Federal de São Carlos, 2017. 72 p.

36. Kato-Narita EM, Nitrini R, Radanovic M. Assessment of balance in mild and moderate stages of Alzheimer's disease: implications on falls and functional capacity. Arq Neuro-Psiquiatr. 2011;69(2):202-7. doi: 10.1590/S0004-282X2011000200012

37. Lee YW, Lee HMD, Chung IS, Yi HA. Relationship between postural instability and subcortical volume loss in Alzheimer's disease. Medicine. 2017;96(25):1-7. doi: 10.1097/MD.0000000000007286

38. Christofoletti G, Oliani MM, Gobbi LTB, Gobbi S, Stella F. Risco de queda em idosos com doença de Parkinson e demência de Alzheimer: um estudo transversal. Rev Bras Fisioterapia. 2006;10(4):429-33. doi: 10.1590/S1413-35552006000400011

39. Ansai JH, Andrade LP, Rossi PG, Takahashi ACM, Vale FAC, Rebelatto JR. Gait, dual task and history of falls in elderly with preserved cognition, mild cognitive impairment and

mild Alzheimer's disease. Braz J Phys Ther. 2017;21(2):144-51. doi: 10.1016/j.bjpt.2017.03.010

40. Manckoundia P, Mourey F, Pfitzenmeyer P, Papaxanthis C. Comparison of motor strategies in sit-to-stand and back-to-sit motions between healthy and Alzheimer's disease elderly subjects. Neuroscience. 2006;137(2):385-92. doi: 10.1016/j.neuroscience.2005.08.079
41. Wei YJ, Simoni-Wastila L, Lucas JA, Brandt N. Fall and fracture risk in nursing home residents with moderate-to-severe behavioral symptoms of Alzheimer's disease and related dementias initiating antidepressants or antipsychotics. J Gerontol A Biol Sci Med Sci. 2017;72(5),695-702. doi: 10.1093/gerona/glw095
42. Hernandez SSS, Coelho FGM, Gobbi S, Stella F. Efeitos de um programa de atividade física nas funções cognitivas, equilíbrio e risco de quedas em idosos com demência de Alzheimer. Rev Bras Fisioter. 2010;14(1):68-74. doi: 10.1590/S1413-35552010000100011
43. Gonçalves J, Ansai JH, Masse FAA, Vale FAC, Takahashi ACM, Andrade LP. Dual-task as a predictor of falls in older people with mild cognitive impairment and mild Alzheimer's disease: a prospective cohort stud. Braz J Phys Ther. 2018;22(5):417-423. doi: 10.1016/j.bjpt.2018.03.011